PLYMOUTH HARBOR
MASSACHUSETTS

SURVEY

(REVIEW OF REPORTS)

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

AUGUST 3, 1961

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54, MASS.

ADDRESS REPLY TO:
DIVISION ENGINEER

REFER TO FILE NO.

3 August 1961

NEDGW

SUBJECT: Survey (Review of Reports) Plymouth Harbor, Massachusetts

TO: Chief of Engineers
Department of the Army
Washington 25, D. C.
ATTENTION: ENGCW-P

1. The subject report is submitted in accordance with EM 1120-2-101, Paragraph 1-126. As the recommendations differ substantially from those in the report previously submitted under date of 18 November 1960, an entire new report is being submitted. There are forwarded under separate cover:

a. Copies 1 to 10 of subject report with letters of transmittal.

b. Five (5) copies of Supplement S-148 in addition to those bound in the report.

c. Three (3) copies of a reduced display map.

d. Three (3) copies of a draft of the public notice of issue of the report. Copies of the public hearing, held 28 January 1959 with five (5) copies of the public notice of the hearing and one (1) copy of the mailing list were forwarded with the original submission, dated 18 November 1960.

2. Copies of the report, with other data required by EM 1120-2-101, are being forwarded directly to the Board of Engineers for Rivers and Harbors.

SEYMOUR A. POTTER, JR.
Brigadier General, USA
Division Engineer

SYLLABUS

The Division Engineer finds that anchorage facilities at Plymouth Harbor are inadequate for the fishing and recreational fleets, both present and prospective. He finds also that benefits to be obtained by provision of sheltered anchorage for these fleets are sufficient to warrant Federal participation in improvement. He recommends, therefore, that the existing project be modified. He considers the proper modification should consist of (a) constructing a stone breakwater extending from a point north of the Town Wharf 1,400 feet in an easterly direction, then turning southeasterly 2,100 feet for a total distance of 3,500 feet, and (b) dredging a 60-acre anchorage basin 8 feet deep south of the breakwater. The estimated first cost of construction (July 1961) is $1,500,000 for the breakwater and anchorage basin, and $1,000 for additional aids to navigation.

The project is recommended subject to the requirement that local interests contribute 20 percent of the construction cost, presently estimated at $300,000. The net cost to the United States is $1,200,000 for construction, $10,000 for pre-authorization studies, and $1,000 for additional navigation aids, with $10,000 additional annual maintenance for the project modification and $120 additional annual maintenance for the navigation aids. The benefit-cost ratio is 1.8.

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SUBJECT: Survey (Review of Reports) Plymouth Harbor, Massachusetts

TO: Chief of Engineers, Department of the Army, Washington 25, D. C.
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AUTHORITY

1. This report is submitted in compliance with the following resolution adopted April 20, 1948, by the committee on Public Works of the United States Senate:

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on Plymouth Harbor, Massachusetts, submitted to Congress on April 6, 1938, and printed as House Document Numbered 577, Seventy-fifth Congress, with a view to determining if any modification of the existing project is advisable at this time."

2. A report of preliminary examination scope was submitted by the Division Engineer, New England on 24 February 1950. The Board of Engineers for Rivers and Harbors reviewed the examination and recommended further study of the need for protected anchorage in Plymouth Harbor.

PURPOSE AND EXTENT OF STUDY

3. Engineering and economic studies have been made to determine the need and economic justification of modifying the existing Federal navigation project in Plymouth Harbor. A detailed hydrographic survey, was made to determine the character and volume of materials to be dredged. Estimates of various types of breakwaters were also made. Available maps, past records, commercial statistics and other data pertaining to the harbor have been studied. Two public hearings were held. The first, held May 12, 1949, was the basis for the Preliminary Examination. The second, held January 16, 1958, represents the views now held by local interests. The information obtained from these hearings has been further supplemented by recent field investigations and discussions with local interests. Changes or additions, requested subsequent to the hearings have been considered in this report.

DESCRIPTION OF NAVIGATION CONDITIONS

4. Plymouth Harbor is located on the east coast of Massachusetts. It is about 45 miles south of Boston Harbor and about 15 miles north of the easterly entrance of the Cape Cod Canal. It is the most southerly of three arms of a large and partially sheltered embayment which is separated from Plymouth and Cape Cod Bays by narrow sand spits. The northerly arm is known as Duxbury Bay, and the westerly arm, Kingston Bay. An outer anchorage, the "Cow Yard", is common to all three arms. The harbor is formed by Long Beach, a low narrow sand spit 1.8 miles long, generally parallel to the mainland, and about a mile from it. The harbor has an area of about 2,000 acres. A large part of it consists of mud flats bare at low tide. The entrance to the harbor lies at the northerly end of Long Beach. From the entrance, a channel 18 feet deep leads across extensive flats to a turning basin opposite the State Pier. The channel then continues, at a depth of 15 feet, to a second turning basin opposite the town Wharf.

5. The mean range of tide is 9.6 feet and the spring range is 11.1 feet. The locality is shown on United States Coast And Geodetic Chart Nos. 245 and 1208, and on the maps accompanying this report.

TRIBUTARY AREA

6. The Town of Plymouth enjoys the distinction of being the oldest continuous settlement of English speaking people in the United States. It has been a permanent community since 1620, the date of the original Pilgrim landing. As such it has become a national shrine with many thousands visiting its shores annually. These visitors come, not only by land, but also by sea, as the harbor is a favorite stopping place for the many yachts that cruise New England waters during the summer recreational season.

7. The town itself is a medium size community, having a population of 13,982 and a real estate valuation of $34,443,950 in 1956. It is the natural trading center for about 40,000 people in surrounding communities. Manufacturing, once the largest source of income, has declined in recent years. The Plymouth Cordage Company located in North Plymouth is the largest rope making concern in the world.

8. Fishing is one of the basic industries. It has shown an upward trend in recent years, increasing in volume to a point where existing facilities are considered inadequate. The industry is an important source of income, employing about 300 to 500 people. Plymouth is ideally located for this industry, situated as it is near prolific fishing grounds both in Cape Cod Bay and off Cape Cod.

9. The summer vacation trade, another major source of local revenue, is important due to Plymouth's national prominence as an historical site. Its natural assets relative to harbor facilities, and its miles of coastline, numerous ponds and extensive woods also

contribute to its recreational value. About 2,000 families are summer residents and about 60,000 tourists visit the locality each year.

10. The locality is well served by excellent highways, bus lines, and by a freight line of the New York, New Haven and Hartford Railroad.

BRIDGES AFFECTING NAVIGATION

11. There are no bridges in the area considered in this report.

PRIOR REPORTS

12. Plymouth Harbor has been the subject of several previous reports. Pertinent data with reference to recent reports are contained in the following tabulation:

Scope and Date of Report	Work Considered	Recommendation
Annual Report of Chief of Engineers for 1899, page 1089	Beach protection along Long Beach	Favorable
House Document No. 1194, 62nd Congress, 3rd Session, 1912	Channel 18 feet deep at mean low water, and 200 feet wide, from harbor entrance to the town wharves	Favorable
House Document No. 996, 66th Congress, 3rd Session, 1921	A channel northwest from Craig's northerly wharf (now State Pier), 15 feet deep at mean low water, 150 feet wide, and 900 feet long, with a turning basin 300 feet square at the end	Favorable
Unpublished Report, dated January 4, 1936	Constructing a breakwater at Manomet	Unfavorable
House Document No. 577, 75th Congress, 3rd Session, 1938	Dredging 18-foot anchorage basin	Favorable
Unpublished Report dated February 24, 1950	15-foot straight channel and anchorage	Unfavorable to channel. Favorable to further study of anchorage.

EXISTING CORPS OF ENGINEERS' PROJECT

13. Prior to the adoption of the existing project, temporary structures were erected for the protection of Long Beach. Dredging the harbor to a depth of 9 feet was also effected. This work was accomplished at intervals during the period from 1824 to 1898, inclusive. The total Federal expenditures under these previous projects amounted to $190,659.80, of which $188,646.59 was for new work and $2,013.21 for maintenance.

14. The existing project was authorized by the following River and Harbor Acts:

Acts	Work Authorized	Documents
March 3, 1899	Beach protection along Long Beach	Annual Report for 1899, page 1089
March 4, 1913	Dredging 18-foot channel	House Document No. 1194, 62nd Congress, 3rd Session
June 20, 1938	Dredging 18-foot anchorage basin	House Document No. 577, 75th Congress, 3rd Session

15. The existing project provides for: (a) protecting by riprap the sections of Long Beach damaged by the storm of November 1898, and restoring Eel River to its former course; (b) dredging a channel 18 feet deep and 200 feet wide, increased at the entrance and at bends, from deep water to the town wharves, (now the site of the State Pier), a distance of about 2.5 miles, with a suitable turning basin at the inner end; (c) dredging a channel 150 feet wide, 15 feet deep, extending in a northwesterly direction about 0.3 mile from the present State Pier, with a turning basin 300 feet square, and of the same depth, at its northwesterly end; (d) maintenance of the area, in the vicinity of the State Pier, between the 15-foot channel and the 18-foot channel which was initially dredged by the Commonwealth of Massachusetts to a depth of 18 feet below mean low water as an item of local cooperation for the 15-foot channel; and (e) dredging an anchorage basin 18 feet deep, 850 feet wide, and 2,125 feet in average length on the southeast side of the 18-foot channel near Long Beach. Maintenance dredging was last accomplished in Fiscal Year 1954. The 18-foot channel was dredged to a 15-foot depth, that depth being considered ample for the existing boating in the harbor. The 15-foot channel was also maintained to that depth. Controlling depths in 1959 were 12 feet for a small area in the entrance channel and 12 feet in the 15-foot channel. Depths in the authorized 18-foot anchorage range from 4 feet above to 18 feet below mean low water.

16. The total cost of new work on the existing project through fiscal year 1960 was $188,571 and $505,560 for maintenance. In addition, $108,400 has been expended from contributed funds. The project is complete except for the 18-foot anchorage. The estimated cost of completing the anchorage is $606,000 (1954). Local interests no longer desire this anchorage in its authorized location. They feel that the need for this anchorage no longer exists due to changed coastwise shipping conditions.

LOCAL COOPERATION ON EXISTING AND PRIOR PROJECTS

17. The River and Harbor Act of March 4, 1913, required that the Commonwealth of Massachusetts, or other local agency, contribute one-half the estimated cost of the 18-foot channel. This condition was accepted by the Commonwealth of Massachusetts on June 16, 1913 when an appropriation of $83,500 was made. This amount was deposited to the credit of the Secretary of War on August 25, 1913. The cost of the completed work being less than the estimated cost by $53,000, one-half of the saving, or $26,500 was returned to the Commonwealth of Massachusetts on March 10, 1916, under provisions of the enabling Act.

18. The authorization by the River and Harbor Act of 1922, for the 15-foot channel extension at Plymouth required that the Commonwealth of Massachusetts or other local interests contribute one-half the total estimated cost of $102,000, construct a wharf and accessories contingent on plans meeting the approval of the Secretary of War and the Chief of Engineers, and dredge an area connecting the existing 18-foot channel with the projected 15-foot channel. The Commonwealth of Massachusetts contributed its share of $51,000, and a wharf with required accessories was constructed by the town of Plymouth. The area connecting the existing 18-foot channel with the 15-foot channel has been dredged.

19. The River and Harbor Act of June 20, 1938, provided for an anchorage basin 18 feet deep on the southeast side of the project channel near Long Beach, contingent on local interests furnishing, free of cost to the United States, spoil disposal areas for the work and for subsequent maintenance as may be required, and contribute one-third the first cost of construction of the improvement. These conditions have not been fulfilled.

OTHER IMPROVEMENTS

20. The town of Plymouth, in 1909, at a cost of $12,000, restored and deepened to 10 feet the 6-foot channel and a portion of the basin completed by the Federal Government under a previous project of 1875.

21. In 1946, the town spent $10,000 for dredging at the Town Wharf. In 1948, the Plymouth Yacht Club basin was dredged at a cost of $30,000. The town and state shared jointly in these costs.

22. In addition to the above, the state and town have spent approximately $120,000 on channels and basins, and approximately $180,000 on the improvement and maintenance of the State Pier and adjacent water-front.

23. In 1911, the Commonwealth of Massachusetts and the town of Plymouth, dredged a channel to the wharf of the Plymouth Cordage Company at the northerly end of the harbor. This channel has a width of 250 feet and depth of 20 feet for about 1100 feet, then a width of 150 feet and a depth of 18 feet for about 5000 feet. The total cost of this work was $143,744.11. This channel is in the same area as the 6-foot Federal channel adopted in 1892 for Kingston Harbor, also known as North Plymouth Harbor. The channel is not physically connected with other dredged channels in Plymouth Harbor.

24. In addition to the above expenditures for channel and basin improvements, large sums of money have been expended in developing the immediate shore line as an historical park around Plymouth Rock. The development was accomplished jointly by the United States Pilgrim Tercentenary Commission, created by a Congressional Resolution approved May 13, 1920, and the Pilgrim Tercentenary Commission of the Commonwealth of Massachusetts. This development included the removal, in 1920, of the nine wharves over which the town's commerce and fishing industry were carried. A new pier was erected at the site of Craig's northerly wharf under the direction of these commissions at an estimated cost of $30,000. The Commonwealth has since acquired this pier and maintains it as a public landing, open to all on equal terms.

25. Further expenditures for dredging were made by the Commonwealth of Massachusetts in 1957, when it dredged a 500 x 600 x 15-foot deep basin southeast of the State Pier. Total cost of this work was approximately $280,000. The first use of this basin was made by the "Mayflower II" on its initial visit to the same harbor in which the original Pilgrim landing was made.

TERMINAL AND TRANSFER FACILITIES

26. There are three wharves in Plymouth Harbor. One is owned by the state, one by the town, and the third by the Plymouth Yacht Club.

27. The Town Wharf is located about opposite the end of the existing dredged channel. It is formed by two sheet-steel pile bulkheads, perpendicular to each other and backfilled to connect with

the shore. Each of these bulkheads has auxiliary wharfage. The first, which is generally perpendicular to the shoreline, has a 250 x 70-foot concrete decked pile and timber structure projecting from it. Berths along this structure have a 14-foot depth. The second has a T-shaped pier projecting obliquely from it. The head of the pier is about 80 feet long. Berthing depths range from 7 to 10 feet. There are four electric hoists located along the wharf. Two fish distributors and a marine service company are located on this facility. Its chief use is commercial. Water and fuel are available. It is open to public use.

28. The State Pier is located about 1300 feet southeasterly from the Town Wharf. It is an L-shaped pile and timber structure, having legs of about 270 feet and 140 feet. The principal berths are at the outer end and have depths of 14 feet. A ramp and float for small boat landings is located at the inner end of the southerly side. This wharf is also open to public use.

29. The Plymouth Yacht Club maintains a wharf located about 2,000 feet southeasterly of the State Pier. This wharf has a total length of about 155 feet, the inner 100 feet consisting of solid fill and the outer portion 55 feet of pile and timber construction. The depth of water at the outer end is 7 feet. Water and fuel are available at this wharf.

30. In addition to these wharves, there are 6 boatyards located along the waterfront. The yards are equipped for boat building and repairs, with a total storage capacity of about 200 boats. Marine railways at these yards can handle boats ranging from 50 to 100 feet in length. Small wharves, used in conjunction with boat repair and construction, are located at these facilities.

IMPROVEMENT DESIRED

31. On the basis of a public hearing held at Plymouth on May 12, 1949, a preliminary examination of Plymouth Harbor navigational improvement was made. Two items of improvement were requested by local interests. One of these items entailed construction of a curved stone breakwater about 1,000 feet east of the town warf and dredging the area between it and the channel to a depth of 18 feet. The basin was requested to provide protected anchorage for the existing and prospective recreational and fishing fleets. The second item consisted of dredging a straight channel from the northwest corner of the proposed anchorage across the mud flats to the entrance at Long Point.

32. The Preliminary Examination, submitted on February 24, 1950, recommended further study of the protected anchorage, and found that provision of the desired channel was not justifiable at that time.

Further study of the protected anchorage was assigned by the Chief of Engineers by letter dated July 3, 1950. The study was deferred until fiscal year 1958 when funds were authorized for its continuance.

33. As the time interval between the submission of the Preliminary Examination and resumption of the study could have produced changed conditions and modifications in the desires of local interests, it was decided to hold a second public hearing. The hearing was held at Plymouth on January 16, 1958. Attendance was excellent and included representatives from local and state Governments, fishing interests, yachting interests, and interested citizens.

34. Local interests reiterated their need for protected anchorage inside the harbor. To effect this protection, it was proposed that a combination earthen causeway and breakwater be erected generally parallel to the shore and connecting to it. The causeway would have a top width of 200 feet with riprap protection on its outer side. The area between the causeway and the existing channel limits would be dredged to a depth of 8 feet, providing about 62 acres of anchorage. Recreational adherents of improvements requested a stone breakwater 1,500 feet long placed immediately south of the existing 18-foot channel and about 1,500 feet offshore. A depth of 8 feet in an area shoreward of the barrier was requested. A stone jetty extending 3,000 feet due east from the northerly end of Long Beach was also requested. Local interests claimed that this jetty would serve to halt the littoral drift of material that flows northward along the beach, finally being deposited in the entrance channel.

35. The anchorage areas and breakwaters are desired to provide a protected anchorage for local fishing boats and pleasure craft, and a harbor of refuge for transient craft. The principal reasons advanced by the proponents of improvement are: (a) that there is no storm protection afforded at the wharves becuase winds veer suddenly from one quadrant to another, with resultant damage to vessels tied at the wharves; (b) there is no safe anchorage in the harbor; (c) the authorized 18-foot anchorage if constructed, would not afford adequate protection from northeast storms which back into the northwest, and the authorized anchorage was designed primarily as a refuge for barges and small tankers which are rapidly being retired from coastwise commerce in this area; (d) available mooring and anchorages are overcrowded, and maneuvering vessels, particularly during storms, is difficult for both commerical and pleasure craft; (e) there is need of a harbor of refuge between the Cape Cod Canal and Boston; and (f) harbor use by both fishermen and pleasure craft will increase if there is adequate protected anchorage.

36. The consensus of local desire for improvement indicated that the authorized 18-foot anchorage is deemed obsolete and no longer necessary. It was stated that the type of coastwise shipping

(towed barges and small self propelled barges) for which this anchorage was designed is rapidly disappearing, and that the anchorage is too inconvenient in location for present boating, which consists of fishing and recreational craft. It was also stated that if possible it would be desirable to abandon the authorized anchorage and substitute for it one of the plans described previously.

EXISTING AND PROSPECTIVE COMMERCE

37. Waterborne commerce, in the portion of Plymouth Harbor under consideration in this study, consists of a single item, fish. The local fishing fleet consists of 19 draggers and 10 lobster-fishing boats. About 20 other lobster boats base in nearby waters and land their catch in Plymouth. In 1957 these boats, as reported by local interests, landed 5,926 tons of ground fish and 171 tons of shellfish, chiefly lobsters. Three distributing firms processed and distributed this fish. The combined capacities of the three plants total 10,000 tons annually. The companies processed and distributed about 9,000 tons of ground fish in 1957. This figure is approximately 3,000 tons above the total ground fish landed at Plymouth. The additional 3,000 tons of fish were landed at various Cape Cod ports and trucked to Plymouth. If protected anchorage were available, the distributors claim that all of this fish could have been landed at Plymouth, resulting in a saving of rehandling and trucking charges.

38. With protected anchorage in Plymouth, local interests predicted that a minimum of 30 draggers would transfer from Cape Cod ports to Plymouth. Reasons advanced for the transfer included; lower trucking charges to Providence, Hartford and New York, the principal markets for Plymouth fish, a diversity of boat repair facilities in the Plymouth area, and better living conditions. In addition, local interests predict that 10 or 12 new draggers would be constructed and introduced into the Plymouth fishing fleet. Definite oral assurances of 3 boats were given, with expectations of at least 4 to 6 more. In addition it was stated that 5 new lobster boats would be added to the fleet.

39. In addition to the new boats discussed above, another type of fishing has been introduced into Plymouth Harbor. In 1957 one fishing boat normally based in Maine, tested gill netting prospects in the vicinity of Plymouth. The boat fished the entire winter season, November through March, and had a successful season. The boat owners deplored the exposed condition of the harbor but stated that if improvements were made, they would return. It was further stated that 4 to 5 boats would return with them as this type of craft usually does not fish in its own locality during the winter season. The return on this type of fishing is very lucrative as the fish caught is steak cod, for which premium prices are paid.

40. In the event of improvement, local fish processors have indicated that plant capacities would be increased to handle the additional tonnage of fish landed by the prospective fishing fleet. It was also indicated that a former fish processor who had been in business prior to the hurricane of 1954 would return should improvement be made. The hurricane of 1954 destroyed his wharf, buildings and 2 draggers.

VESSEL TRAFFIC

41. Reported commercial statistics for Plymouth Harbor and North Plymouth, as a unit, indicated 1,738 vessel trips in 1957. Because a large proportion of trips by smaller craft is not reported and no distinction is made between Plymouth and North Plymouth, the reported traffic is not considered indicative of traffic in Plymouth Harbor.

42. The trips to Plymouth Harbor consist chiefly of fishing vessels and recreational craft. In Plymouth, draggers average 250 round trips per year which, for the 19 boats engaged, would aggregate 9,500 vessel trips. This figure was obtained from local interests. A total of 30 lobster boats land their catch in Plymouth on approximately 125 days of a 150 day lobster season. This would add about 7,500 more vessel trips. The locally based recreational fleet of 391 boats averages 2 round trips per week for about 16 weeks or about 25,000 vessel trips. The present transient recreational fleet of about 200 boats would add an additional 400 vessel trips.

43. The total of the above described vessel trips amounts to an estimated 42,400 vessel trips for the harbor. With improvement effected, local interests predict a hundred percent rise in vessel trips.

DIFFICULTIES ATTENDING NAVIGATION

44. The principal difficulty attendant on navigation stems from the exposed condition of the harbor. Northerly winds have a fetch of about 6 miles across the harbor. Storms from this direction are usually the most severe and cause considerable damage to boats, both in the anchorages and at the wharves. Local interests report that severe northeast storms with high wave action have caused considerable damage, breaking boats loose from their moorings with resultant groundings and pounding on the shore.

45. It has also been reported locally that during recent hurricanes several transient boats sought refuge in Plymouth. A considerable portion of these boats incurred severe damage due to the lack of adequate protected anchorage.

WATER POWER AND OTHER SPECIAL SUBJECTS

46. Water power, flood control, pollution or other related subjects are not pertinent to this report. The Massachusetts Division of Fisheries and Game has advised that any spoil disposal in the nearby marsh areas (or harbor flats) would destroy the high value of one of the most valuable migratory waterfowl habitats on the Massachusetts shoreline. The report of the U. S. Fish and Wildlife Service, favorable to improvement is shown in Appendix "B" of this report.

PLAN OF IMPROVEMENT

47. Several plans of improvement have been considered in this report. The first, advocated by local interests, consists of 3 breakwaters and two anchorages. One breakwater in the inner harbor would be formed by a sheet steel pile bulkhead about 4,400 feet long. The bulkhead would extend from town-owned property north of the Town Wharf for a distance of about 1,300 feet due east, then continue southeasterly for about 3,100 feet, generally parallel to the developed shoreline. The area shoreward of the bulkhead would be dredged to a depth of 8 feet, forming a protected anchorage of about 62 acres. The spoil from the dredged anchorage would be deposited seaward of the bulkhead to form a causeway with a top width of 200 feet and side slopes of 1 vertical on 3 horizontal. The side slopes would be riprapped. The plan also included a rubble stone breakwater south of the existing 18-foot channel and about the same distance from shore. This breakwater would have a top width of 5 feet and 1 on 1 side slopes. Dredging of an anchorage basin shoreward of this breakwater would also be required forming an anchorage of about 72 acres. A jetty 3,000 feet long extending due east from Long Point was also considered with this plan, as requested.

48. A study of this plan was made. The study revealed that, although the structures proposed inside the harbor would provide the protected anchorage desired, costs would be excessive and incapable of economic justification. The jetty proposed for the tip of Long Beach would serve its function of arresting the littoral drift of sand that currently tends to shoal the entrance channel to the northward. However, the annual costs incurred in providing the jetty would exceed the current annual costs of maintaining the channel. The cost of this plan is given under "Estimates of First Cost for Comparative Purposes". Study was also made of a shorter jetty about 1,300 feet long. It was found that this jetty would be inadequate over the anticipated life of the project, requiring extension periodically as the storage area south of it became filled. First cost of such a jetty plus periodic extensions would also result in annual charges, exceeding annual charges now incurred in maintenance of the channel. Estimates of such charges result in a benefit-cost ratio of about $1,600 : $2,500, or 0.6.

49. Alternate plans of improvement were studied with consideration given to the various factors for which improvement is desired. These factors include; the necessity for protected anchorage for the current and prospective fleets, the direction from which storms of high wind velocity most frequently occur, the fetch of open water over which these winds would generate maximum wave heights, and the most economical structure that would provide the desired protection. From the alternate plans of improvement, one was selected which, it is considered, will overcome the navigational difficulties extant in the harbor.

50. The selected plan provides for a stone breakwater about 3,500 feet long, enclosing an anchorage of about 60 acres. The breakwater would extend easterly from a point north of the Town Wharf for a distance of 1,400 feet, where its direction would change southeasterly for an additional distance of 2,100 feet. Between this structure and the main harbor channel, an anchorage of about 60 acres would be dredged to a depth of 8 feet. Design height of the breakwater was fixed at 15.0 feet, based on a maximum tide of 12 feet, a design wave of 3.5 feet and a fetch of 6 miles. The limit of the enclosed anchorage would be about 75 feet from the toe of the breakwater. Primarily, the breakwater would provide protection from winds emanating from northerly directions. These winds have the greatest fetch and generate the maximum wave heights in the harbor. Waves from easterly directions are estimated to generate waves of 1.5 to 2 feet in height. While these waves of themselves are not as significant, they could cause damage in an anchorage in which boats are closely moored. Therefore, the breakwater's direction was altered to afford protection from this latter direction. The breakwater would also protect boats moored at the wharves. Local interests report considerable damage from this source in the past.

51. The size of the anchorage was designed for the current and prospective fleets, both commercial and recreational. The current recreational fleet at Plymouth consists of 391 boats, including outboards, inboards, cruisers, auxiliaries, and sailboats. The fishing fleet numbers 19 draggers and 10 lobster boats, based in the harbor. Current transient boats are equivalent to 6 boats per season. Prospective additions to the fleets include 8 draggers, 5 of which will be transfers, 5 lobster boats, 110 additional recreational craft, 14 additional transient boats, and 202 boats, due to normal growth over the project life. This should result in an aggregate population of about 765 boats at the end of project life. It is estimated that a 60-acre anchorage could accommodate about 600 boats leaving 165 boats at their present moorings in the State-dredged anchorages.

52. Basically, the chief element of navigational improvement consists of protection from the severe northerly storms that occur in Plymouth Harbor. Therefore, breakwater protection was provided in

all plans studied, including the selected plan. However, regardless of protection, the existing anchorage areas are not spacious enough to accommodate the existing fleet. In view of this factor, various sizes of anchorages were studied. In addition, different combinations, such as anchorages exclusively, anchorages combined with marinas, and marinas exclusively were studied. It was found that the most economical method of providing mooring space was provision of anchorage. Estimates of cost of each plan were made on a per boat basis. During computation of these estimates, it was found that marina construction in harbors north of Cape Cod, where the mean range of tide is 9 feet or more, is much more expensive than harbors southward. The cost per boat of the 60-acre anchorage is about $1,400. The cost per boat for marina and anchorage combinations ranged from $1,975 to $2,600. The cost per boat of marinas alone with connecting channels and basins was in excess of $2,700. Therefore, the 60-acre anchorage was selected as the most justifiable.

REQUIRED AIDS TO NAVIGATION

53. The United States Coast Guard has been consulted and has advised that 1 additional unlighted buoy will be required to mark the junction of channel and anchorage. The estimated first cost of the buoy is $1,000 with annual maintenance of $120.

ESTIMATES OF FIRST COST

54. Estimates of first costs of construction have been made for both the desired and alternate plans of improvement. The estimate for the desired plan is shown for informative and comparative purposes only. This plan will not be considered further in the report. Federal construction would include all work in connection with the breakwater, and the basin plus required aids to navigation. Prices include contingencies and are based on price levels prevalent in July 1961. Details of Costs are shown in Appendix "A".

PROJECT CONSTRUCTION

A.	DESIRED IMPROVEMENT	
	(1) Sheet Steel Pile Bulkhead	$ 1,092,000
	Causeway	1,220,000
	Outer slope, Riprap	91,000
	(2) Stone breakwater (1,500' long)	228,000
	Dredging*	834,000
	(3) Breakwater at Long Point	506,000
	Engineering and Design	29,000
	Supervision and Administration	200,000
		$ 4,200,000
B.	ALTERNATE IMPROVEMENT	
	(1) Rubble Stone Breakwater*	$ 610,000
	(2) Basin (Dredging)*	784,000
	Engineering and Design	20,000

Supervision and Inspection	$ 86,000
Total project construction cost	$ 1,500,000
Aids to navigation	1,000
Pre-authorization Studies	10,000
Total Project Cost	$ 1,511,000

* Includes Contingencies

SHORELINE CHANGES

55. The west or mainland shore of Plymouth Harbor consists partly of narrow beaches fronting moderately steep upland and partly of marsh areas. In the vicinity of improvement, the shore is developed and protected by seawalls, riprap, and bulkheads. This shore appears to be stable. The easterly inner shore is part of a long sand spit stabilized by a stone mound running along almost its entire length. This shore is subject to local wind wave action and minor currents. Depletion of the materials on this spit has been arrested by various structures. Therefore, it is considered that improvement would not contribute to any significant erosion of this shore. The harbor bottom is composed of mud and sand flats, the major portion of which are above the plane of mean low water. No appreciable change has occurred in the elevation of the flats since 1910, as evidenced by comparison of a Corps of Engineers' survey of that year with the latest U.S. Coast and Geodetic Survey Chart. In view of the small amount of littoral movement of materials, it is considered that shoaling of the anchorage will be minor. It is not considered that construction of a breakwater in the location considered will have any appreciable effect on the shore.

ESTIMATES OF BENEFITS

56. Benefits to be derived from improvement of Plymouth Harbor by provision of protected anchorage will be in part general and in part recreational. General benefits will accrue from reduction in storm damage to fishing vessels and additions to the fishing fleet, both in new boats and in transfers from other harbors. Recreational benefits will result from elimination of storm damage to recreational craft, increased use of the harbor by the present local and transient fleets, and by additions to those fleets as a result of the improvement.

57. As stated previously under Existing and Prospective Commerce, it is estimated that 3 new draggers and 5 new lobster boats will be

added to the present fishing fleet immediately after improvement. This addition will increase fish landings in Plymouth Harbor by an estimated 16 percent for ground fish and 17 percent for shell fish. Comparison of the present total landings of ground fish with the number of boats engaged indicates average annual landings of about 314 tons per boat. This figure agrees substantially with the statement of local interests to the effect that the annual average catch per boat was 625,000 pounds. The annual average trips involved in making this catch are 250.

58. In consideration of the claimed annual average catch, the 3 new boats would land a total of 3 x 2500 x 250 or 1,875,000 pounds of fish. The average weighted ex-vessel price, of fish landed in Plymouth is estimated at $.056 per pound. This price is based on average weighted, ex-vessel fish prices landed at Boston during 1957 as reported by the Department of Interior, Fish and Wildlife Service. Prices ranged from $0.0372/lb. for Whiting to $0.156 for Black Backs. Thus the gross value of additional fish caught would be 1,875,000 x .056 or $105,000. In consideration of reasonable crew wages, operating costs, annual carrying charges, and maintenance of the fishing boats, it is estimated that 60 percent of the gross or ex-vessel value of the fish is absorbed by these factors, and the remaining 40 percent represents the net value. In this case, the net value would be $105,000 x 0.40 or $42,000, a general benefit for improvement.

59. In the event of provision of protected anchorage, local interests claim transfer of about 30 draggers from Provincetown and other Cape Cod points. It was claimed that the present exposed condition of the harbor is the only deterrent to immediate transfer. As justification for the claim, it was shown that trucking charges from Plymouth to the markets west and southwest which are served by Cape Cod ports average $0.57 per 125 pound case less than other Cape Cod ports. Local dealers assert that this saving is passed on to the local boats. Additional running time for boats to Plymouth is not a factor since the distances to the various fishing grounds average about equal for the ports concerned. In consideration of the savings in truck charges, it is estimated that at least five of the claimed transfers can be expected to transfer to Plymouth immediately after improvement. Since the average annual catch of the boats is 625,000 pounds, the total annual catch would be 5 x 625,000 or 3,125,000 pounds. At $0.57 per 125 pounds saving in trucking charges, the savings would amount to $0.57 x 3,125,000 ÷ 125 or $14,300 a general benefit.

60. No actual records of storm damage to boats has been kept in recent years. Prior to 1949, the town had records of boats that were damaged, although no monetary evaluation of the damage was shown.

Estimates of all of the recorded damages were made in 1950. The estimates showed on annual average boat damage from storms, exclusive of hurricanes, of $5,600 at 1950 price levels. Since the major portion of this damage occurred during war and immediate post-war years, when recreational boating was practically non-existent and the fishing fleet was smaller, the figure of $5,600 is not considered indicative of present annual average boat damage. It is estimated that the damage is now more extensive, as fleets have increased in numbers. This results in a higher incidence of damage. The boat repair cost-index is also higher. In consideration of these factors, it is estimated conservatively that annual average boat damage amounts to $15,000. Of this damage, 50 percent has been assigned to the fishing fleet and 50 percent to the recreational fleet. This assignment is based on the fact that the fishing fleet has a much higher degree of exposure, particularly during the winter season when the frequency of storms becomes greater than in other seasons. It is estimated that protected anchorage will eliminate at least 80 percent of the total damage, providing benefits of $12,000 to both recreational and fishing boats. In addition to the estimated annual average boat damage, considerable havoc has resulted from hurricanes of record. Local interests cited 3 such storms in which boat damage ranged from $50,000 to $250,000. While the breakwater would not entirely eliminate such damage, it is considered that the breakwater will alleviate it in great part.

61. In 1957, a Maine transient fishing boat explored the possibilities of gill-netting steak codfish out of Plymouth. The boat fished from October through March for a total of 16 weeks. It averaged from 4 to 5 days fishing per week for a total catch of about 144,000 pounds of fish. The boat operators were very gratified with the results of the fishing venture, but were very concerned about lack of protection in the harbor. This type of fishing boat does not usually fish during the winter months. Therefore, the added fishing at Plymouth resulted in additional earnings for the boat. The boat owners stated that when protected anchorage becomes available, at least 3 additional boats, of this type, will operate out of Plymouth during the winter months in lieu of laying-up. No benefits from this source have been evaluated, as it is considered that various other factors, other than protected anchorage, would induce these fishermen to return. However, it is believed that protected anchorage would be of benefit for this type of fishing, if pursued in the future.

62. Local interests report a fleet of 30 active full-time lobster fishing boats operating in the vicinity of Plymouth with all of the fleet landing their catch in the harbor. Not all of the boats base in Plymouth. About 20 base in the nearby localities of

Kingston, Duxbury, and Cedarville, a section of Plymouth south of the harbor. The 10 remaining boats base in the harbor. The 20 boats, not based in the harbor, are reported to consume an average of one hour's extra time returning to their moorings. It was stated that these boats would transfer to Plymouth in the event of improvement. Investigation of this claim reveals that the boats presently base at their respective locations for personal reasons such as, proximity to their homes, which allows for quicker access to the boats in the event of storms. It is doubtful if any of these boats would transfer to Plymouth in the event of improvement. Therefore, no benefits can be derived for these boats. For the 10 boats which base in Plymouth, no benefits other than elimination of storm damage, which has been included in the overall storm damage estimated previously, will be derived. However, it is estimated that 5 new lobster boats will be added to the fleet after improvement.

63. It is reported that lobster fishermen operate out of Plymouth Harbor 7 days per week from May through September. This would result in an overall season of about 150 days. It is estimated that about 16 percent of this season or 25 days is lost time due to such factors as adverse weather conditions, emergency repairs, and time for ordinary care and maintenance of the boat. The average daily catch per boat was stated to be 200 pounds. This figure is based on the reported operation of 200 to 400 traps by each full-time lobster-fisherman. It is considered that a daily catch of 200 pounds could not be maintained over the entire season. A more reasonable daily average is estimated at 100 pounds based on reported landings compared with the number of boats. This average is comparable to reported landings of lobster boats in other fishing harbors along the New England coast. For the 125 days of actual fishing, the boats average 100 x 125 or 12,500 pounds annually. The average ex-vessel price of lobsters at Plymouth has been determined to be $0.50 per pound. This price was based on past records of local dealers. The gross value per boat of the annual catch is $0.50 x 12,500 or $6,275. It is estimated that, similar to the dragger fleet, the net value of the catch is 40 percent of the gross after wages and expenses are deducted. Thus the net value per boat becomes $6,275 x 0.40 or $2,500. For the 5 additional boats that would base in Plymouth Harbor, the general benefit to be derived would be $2,500 x 5 or $12,500.

64. Benefits for the recreational fleet have also been estimated. The benefits have been evaluated as the gain in annual for-hire return which owners of the craft would enjoy, if improvement were made. The value of this gain is expressed as a percentage of the current value of the fleet. The gain represents the difference between present use of the harbor and the increased use that will be made possible as a result of improvement. Ideal return varies according to the size and type of boat. For this report, the ideal return ranged from 12 percent for outboard motors to 8 percent for the largest boat.

In determination of the value of the ideal return, consideration was given to the lack of protected anchorage, and the extent to which full use of the harbor was precluded by its unavailability. Consideration was also made of the lack of sufficient anchorage to accommodate the existing fleets, both local and transient.

65. At the present time, anchorage is confined to 2 basins dredged by the Commonwealth of Massachusetts, and a natural hole known as, "Hobshole Channel". Depths in this hole range from 7 to 18 feet. The basins have been dredged to 6 and 15 feet. All the anchorages are exposed to winds emanating from the northeast and northwest quadrants. The basins are usually filled to capacity by both the local fishing and recreational fleets. Transient boats are usually assigned anchorage in the, "Cow Yard", when the basins are filled. The "Cow Yard" is a comparatively deep area at the entrance, directly exposed to ocean swells. In an easterly storm or sudden squall, the location is prohibitive. Therefore, transient boats usually proceed to other harbors rather than anchor in this location. Provision of protected anchorage would eliminate this harbor deficiency and allow for recreational benefits.

66. The recreational boating season in Plymouth is reported to average about 100 days annually, or from May to September. This season is somewhat shorter than other recreational harbors in the vicinity enjoy. The chief reason for the abbreviated season is attributed to lack of protected anchorage. Local interests claim that in the past, a considerable amount of storm damage occurred during the autumnal months of September and October. Therefore, to obviate any possibility of storm damage, a large portion of the recreational fleet is hauled out and stored for the winter months. This claim appears reasonable as severe equinoctial storms occur during that period. It was also claimed that a considerable part of the damage was suffered by boats which had sought refuge there. With protected anchorage, the season can be extended 20 to 30 days, providing for increased use of the harbor immediately after improvement. Benefits from this source are estimated to total $10,600 as detailed in table I.

67. Provision of protected anchorage will allow for normal growth of the recreational fleet. This growth is now restricted by lack of anchorage space. Numerous requests for permanent mooring space have been made and have had to be denied because of lack of mooring space. The harbor is popular in southeastern Massachusetts, as evidenced by the growth of the recreational fleet in recent years. In spite of its disadvantage of being unprotected, the recreational fleet has increased from 200 boats in 1950 to 391 in 1958, an increase of 91 percent. Local interests claim this number

is the maximum that can be accommodated under present conditions. With normal growth, it is conservatively estimated that the fleet will increase about 50 percent over a 50-year period, the anticipated life of the project. Since these boats will realize the full benefit of protected anchorage, ideal return to the boats will occur in the event of improvement. However, since the benefits will be realized gradually over the life of the project, the benefits are reduced to their annual average equivalent, which amounts to $34,600 x .40498 or $14,000. Benefits for normal growth for the recreational fleet are detailed in table III.

68. Discussion with local interests developed the fact that many recreational craft had applied for permanent moorings in the harbor, but had been denied such space due to the lack of anchorage area. It was further reported that at least 200 to 300 boats would be immediately added to the fleet if protected anchorage were provided. This estimate is considered overly-optimistic. However, in view of the harbormaster's records of applications for mooring and the yacht club's declaration, relative to additions to its flotilla, it is considered that 110 new boats will be added to the local fleet immediately after improvement. Classification of these additional boats results in an additional fleet of 50 outboards, 10 inboards, 25 cruisers, 5 auxiliary sail, and 20 sailboats. As these boats will be new boats, not presently based elsewhere, it is estimated that 100 percent of the ideal return will be realized for them and constitute a recreational benefit. Benefits estimated for these boats aggregate $11,600 as detailed in Table II.

HARBOR: Plymouth Harbor TABLE I. BENEFITS TO RECREATIONAL BOATING

Locally-based Fleet

TYPE OF CRAFT	LENGTH (Feet)	NO. OF BOATS	DEPRECIATED VALUE AVERAGE $	DEPRECIATED VALUE TOTAL $	PERCENT RETURN IDEAL	PERCENT RETURN % OF IDEAL Pres.	PERCENT RETURN % OF IDEAL Future	GAIN	VALUE $	ON CRUISE AVG. DAYS	ON CRUISE % OF SEASON	ON CRUISE VALUE $
RECREATIONAL FLEET												
Outboards	10-20	216	750	162,000	12	100	100	-	-	-	-	-
Inboards	10-20	6	2,500	15,000	12	85	100	1.8	270	-		
Cruisers	15-30	18	3,000	54,000	9	85	100	1.35	729			
	31-50	47	6,000	282,000	9	85	100	1.35	3,807	30	25	952
	51-60	17	10,000	170,000	9	85	100	1.35	2,295	30	25	574
Aux. Sail	15-30	5	4,000	20,000	9	85	100	1.35	270	-	-	-
	31-40	3	8,000	24,000	9	85	100	1.35	324	30	25	81
	41-60	2	15,000	30,000	9	85	100	1.35	405	30	25	101
Sailboats	10-20 21-30 31-40 41-60	54	500	27,000	12	85	100	1.8	486	-		
CHARTER BOATS												
Cruisers	21-35	5	5,000	25,000	12	85	100	1.8	450	-		
	36-50	15	8,000	120,000	12	85	100	1.8	2,160	-		
	51-100	3	20,000	60,000	12	85	100	1.8	1,080	-		
TOTALS		391				12,276-1708=10,568			12,276		Say 10,600	1,708

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HARBOR: Plymouth Harbor TABLE II. BENEFITS TO RECREATIONAL BOATING (Additions)

TYPE OF CRAFT	LENGTH (Feet)	NO. OF BOATS	DEPRECIATED VALUE AVERAGE $	DEPRECIATED VALUE TOTAL $	PERCENT RETURN IDEAL	% OF IDEAL Pres.	% OF IDEAL Future	GAIN	VALUE $	ON CRUISE AVG. DAYS	ON CRUISE % OF SEASON	ON CRUISE VALUE $
RECREATIONAL FLEET												
Outboards	10-20	50	750	37,500	12	0	100	- (1)		-	-	-
Inboards	10-20	10	2,500	25,000	12	0	100	12	3,000			
Cruisers	15-30	20	3,000	60,000	9	0	100	9	5,400	30	25	1,350
	31-50	5	6,000	30,000	9	0	100	9	2,700	30	25	675
	51-60											
Aux. Sail	15-30	5	4,000	20,000	9	0	100	9	1,800	30	25	450
	31-40											
	41-60											
Sailboats	10-20	20	500	10,000	12	0	100	12	1,200	10	10	120
	21-30											
	31-40											
	41-60											
CHARTER BOATS												
Cruisers	21-35											
	36-50											
	51-100											
TOTALS		110							14,100			2,595

14,100-2,595=11,505 Say $11,600

(1) No benefit taken for outboards.

HARBOR: Plymouth Harbor TABLE III. BENEFITS TO RECREATIONAL BOATING (Gradual Growth)

TYPE OF CRAFT	LENGTH (Feet)	NO. OF BOATS	DEPRECIATED VALUE AVERAGE $	DEPRECIATED VALUE TOTAL $	PERCENT RETURN IDEAL	% OF IDEAL Pres.	% OF IDEAL Future	GAIN	VALUE $	ON CRUISE AVG. DAYS	ON CRUISE % OF SEASON	ON CRUISE VALUE $
RECREATIONAL FLEET												
Outboards	10-20	110	750	82,500	12	0	12	12	-(1)		-	
Inboards	10-20	4	2,500	10,000	12	0	12	12	1,200		-	
Cruisers	15-30	9	3,000	27,000	9	0	9	9	2,430	10	10	245
	31-50	23	6,000	138,000	9	0	9	9	12,420	30	25	3,105
	51-60	8	10,000	80,000	9	0	9	9	7,200	30	25	1,800
Aux. Sail	15-30	3	4,000	12,000	9	0	9	9	1,080	30	25	270
	31-40	2	8,000	16,000	9	0	9	9	1,440	30	25	360
	41-60	1	15,000	15,000	9	0	9	9	1,350	30	25	340
Sailboats	10-20	27	500	13,500	12	0	12	12	1,620		-	
	21-30	4	1,500	6,000	12	0	12	12	720		-	
	31-40											
	41-60											
CHARTER BOATS												
Cruisers	21-35	2	5,000	10,000	12	0	12	12	1,200			
	36-50	8	8,000	64,000	12	0	12	12	7,680			
	51-100	1	20,000	20,000	12	0	12	12	2,400			
									40,740			6,120
TOTALS		202							40,740-6,120=34,620			Say 34,600

(1) No benefit taken for outboards.

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69. The present transient recreational fleet of about 250 boats visiting Plymouth Harbor is reported to average a stay of about 2 to 3 days per boat. However, in 1958 over 1,000 boats visited Plymouth Harbor. The greater portion of these boats requested mooring space and had to be refused for lack of anchorage. This traffic in transient boating is not considered normal under present conditions of unprotected anchorage, as in 1956 the harbormaster reported a total of only 210 boats visiting the harbor. The increase in transient boating in 1958 is attributed to the presence of the "Mayflower II", a replica of the original Mayflower, which attracted an unusual number of visiting craft. While the increase in transient boating from this source is not expected to maintain its present volume, it is considered that a percentage of the increase will continue. The percentage of increase is estimated as 50 percent of the increase in 1958 over 1956 or a 400-boat increase. Consideration of this estimate was made on the basis of the added attractiveness of the locality as a national shrine.

70. As stated previously, transient boating is hampered in the harbor by lack of anchorage space. In normal years 200 to 300 boats are denied anchorage space for overnight stays. In consideration of this factor and the normal growth of boating, it is estimated that an additional 400 boats will visit Plymouth Harbor for stays of at least 2 or more days.

71. The total of the above described transient visits will result in an anticipated transient fleet of 1,000 boats annually. This total reflects the 200 boats normally using the harbor, the 400-boat increase attributed to visits of historical significance, and the 400-boat increase resulting from provision of additional anchorage. For the 120-day transient boat season this will amount to an estimated 2,400 boat days or the equivalent of 20 permanent boats. Benefits for these boats are detailed in Table IV.

TABLE IV BENEFITS TO TRANSIENT RECREATIONAL BOATING
(Existing and Prospective)

Type of Craft	Length	No. of Boats	Depreciated Value Average	Depreciated Value Total	% of Ideal Ideal	% of Ideal Pres.	% of Ideal Future	Gain	Value
Cruisers	31-50	10	6,000	60,000	9	80	100	1.8	1080
	51-60	5	20,000	100,000	9	80	100	1.8	1800
Aux. Sail	31-40	3	20,000	60,000	9	80	100	1.8	1080
	41-60	2	25,000	50,000	9	80	100	1.8	900
									4860
TOTALS		20				Say 4,800			

72. Plymouth Harbor is the largest harbor between the eastern end of the Cape Cod Canal and Boston Harbor. Its location and storm protection are such that it makes an excellent refuge from southeasterly and easterly storms. Boats in transit between the two points or to northern ports often seek refuge in such storms. However, in severe northeast and northwest storms refuge is not practicable as no protection is afforded from these storms which generate local wind waves of 3 to 4 feet in height. Considerable boat damage has been incurred in 3 recent hurricanes by boats who sought refuge in Plymouth. For the purpose of this report, no evaluation of annual damage, attributable to this source, has been made because of the inherent difficulties in compiling records of it. However, it is believed that considerable benefits accruing from provision of a harbor of refuge from these storms will be derived.

73. The benefits described above are summarized in the following table:

TABLE V

Source	General	Local	Total
3 Additional draggers	$ 42,000		$ 42,000
5 Transferred draggers	14,300		14,300
Reduction in Storm Damage	9,000	$ 3,000	12,000
5 Additional Lobster Boats	12,500		12,500
Local Recreational Fleet, (increased use, plus gradual growth)	12,300	12,300	24,600
110 New Recreational Boats	5,800	5,800	11,600
Present and Anticipated Transient Recreational Fleets	2,400	2,400	4,800
Total	$ 98,300	$ 23,500	$121,800

74. The estimated annual charges for the considered improvement are based on an anticipated project life of 50 years, at interest rates of 2.625 percent for the Federal Government and 3.5 percent for local interests. Additional annual maintenance charges are based on costs experienced in maintenance of the existing project. The computation of annual charges is detailed below:

Federal Annual Charges		
(a)	Corps of Engineers	
	Interest (1,210,000 x .02625)	$ 31,844
	Amortization (1,210,000 x .00989)	12,000
	Additional Annual Maintenance	10,000
(b)	United States Coast Guard	
	Interest and Amortization (1000 x .03614)	36
	Additional Annual Maintenance	120
	Total Federal Charges	$ 54,000
Non-Federal Charges		
	Interest (300,000 x .035)	$ 10,500
	Amortization (300,000 x .00763)	2,300
	Total Non-Federal Charges	$ 12,800
	Total Annual Charges	$ 66,800

COMPARISON OF BENEFITS TO COSTS

75. Comparison of the estimated annual benefits of $121,800 with the estimated annual carrying charges of $66,800, results in a benefit cost ratio of 1.8.

APPORTIONMENT OF COSTS AMONG INTERESTS

76. Construction costs for navigational facilities have been apportioned among interests in proportion to the benefits received. Since the ratio of evaluated general benefits to local benefits is 80 percent to 20 percent, construction costs have been apportioned in the same ratio. The apportionment of costs is shown as follows:

Federal

Corps of Engineers, General navigation facilities (0.80 x 1,500,000)	$1,200,000
Pre-authorization Studies	10,000
Sub-Total	$1,210,000
U. S. Coast Guard Aids to Navigation	1,000
	$1,211,000

Non-Federal

Local Cash Contribution ($1,500,000 x 0.20)	300,000
Total Project Cost	$1,511,000

77. The estimated additional annual maintenance costs of $10,000 for dredging and $120 for navigation aids are considered to be Federal costs to be incurred by the Corps of Engineers and the U. S. Coast Guard.

PROPOSED LOCAL COOPERATION

78. Local interests should provide, without cost to the United States, all lands, easements, and rights-of-way necessary for construction and maintenance of the project when and as required. Local interests should also hold and save the United States free from damages that may result from either the construction works or maintenance.

79. There are 2 public landings in the area considered for improvement, the Town Wharf and the State Pier. Both of these have suitable supply facilities and have been offered as public landings, open to all on equal terms. Therefore, no additional public landing is necessary. However, it is considered that local interests should provide, without cost to the United States, all necessary mooring facilities in the anchorage.

80. The benefits to be derived from improvement of Plymouth Harbor are partly local and partly general in nature. Local benefits are estimated as 20 percent of the total benefits. Since it is considered that local interests should share in the project costs commensurate with the local benefits to be derived, it is considered that local interests should make a cash contribution of 20 percent of the construction cost of the project, exclusive of aids to navigation. The local cash contribution is estimated at $300,000 (1961). Provision of and maintenance of navigation aids are

considered to be a Federal responsibility. Local interests have been consulted and have provided reasonable assurance that the above described requirements of local cooperation would be met.

COORDINATION WITH OTHER AGENCIES

81. All Federal, State, and local intersts having an interest in improvement of Plymouth Harbor were notified of the public hearings held 12 May 1949 and 16 January 1958. Representatives of the town of Plymouth, the Commonwealth of Massachusetts, and the U. S. Coast Guard have been consulted throughout the study concerning the effects of the proposed improvement on their activities. Fish and wildlife agencies, both Federal and State, have been consulted. Their comments are contained in Appendix "B" of this report.

DISCUSSION

82. Plymouth Harbor is one of the more active small-boat harbors in Massachusetts, serving the needs of both commercial fishing and recreational boating. It lies about 45 miles southeast of Boston Harbor and about 15 miles northwest of the east entrance to the Cape Cod Canal. It is used frequently as a harbor of refuge from the sudden easterly squalls which occur along the Massachusetts coast. Its prominence as a national shrine contributes greatly to its value as a tourist attraction; many thousands of tourists visit it during the summer vacation season. Among the visitors are transient boats, many of which are unable to remain overnight because of inadequate anchorage conditions.

83. The town of Plymouth, the immediate tributary area, has a permanent population of about 14,000. Its real estate valuation in 1956 was $31,443,950. The population is augmented in the vacation season by about 2,000 summer resident families, and about 60,000 tourists. There are 3 wharves of which two are used commercially and the remaining one serves the yacht club. There are also six boatyards used primarily for storage, repair and servicing of boats. Most of these yards have attendant wharfing facilities.

84. There is considerable local interest in harbor improvements as evidenced by past local expenditures on harbor development. In addition to cash contributions on several Federal improvements, local interests have expended in excess of $600,000 for navigation and waterfront improvements. The net result of such expenditures includes 2 small anchorages, seawalls and riprap protected shores. The Town Wharf has been improved and increased in size sufficiently to handle the unloading of about six draggers simultaneously. Two wholesale fish processing establishments are located on the wharf.

85. Fish is the chief item of commerce in the portion of the harbor under consideration. In 1957, according to local reports, 5962 tons of groundfish and 171 tons of shellfish were landed by a fleet of 19 draggers and 30 lobster boats. Three wholesale fish dealers handled this commerce. In addition to the landings, the three dealers report an additional 3,000 tons of fish trucked into Plymouth from other Cape Cod ports. It was claimed that the major portion of this additional catch would be landed at Plymouth in the event of improvement.

86. The chief desire for improvement, as developed by the second public hearing in 1958, consists of additional protected anchorage. Local interests report that the lack of such anchorage precludes expansion in boating activity in the harbor. As justification for improvement, boat damages during 3 recent hurricanes were cited. Local estimates of such damages amounted to more than $500,000. Damages due to storms other than hurricanes were also cited. Storms of the greatest wind velocity are usually from a northeasterly or northwesterly direction. Such storms have a fetch of about 6 miles over open water and at high tide generate local wind waves with heights from 3.5 to 4.0 feet maximum. It was stated that such storms cause boats to break away from moorings and go aground with resultant damage. Boats tied to wharves are also damaged by the wave action. Estimates of damages incurred by such wave action amount to $15,000 annually.

87. To obviate such damages and provide for expansion of both the recreational and fishing fleets, local interests proposed that a combined causeway and barrier be erected. The causeway would have a top width of 200 feet, be bulkheaded on the shoreward side, to retain the fill, and riprapped on its outer face. It would extend easterly for about 1,300' then southerly for about 3,100 feet. The area west of the breakwater would then be dredged to a depth of 8 feet to provide an anchorage basin about 62 acres in area. Fill for the causeway would be available from the dredging of the basin. As a supplement to this plan for protection of the harbor south of the main channel, it was proposed that a stone breakwater be constructed. This breakwater would be about 1,500 feet from the shore, generally parallel to it, and about 1,500 feet long. An 8-foot basin would be provided west of this breakwater. An impervious jetty on the tip of Long Beach was also proposed. This jetty would have the effect of arresting the littoral drift that now tends to flow northward, with resultant shoaling of the entrance channel.

88. Studies made of the desired improvement revealed that although the desired protected anchorages, and structures would be adequate, the costs of construction would be relatively high and incapable of economic justification. Therefore, an alternate plan

of improvement was studied. The alternate plan consists of a rubble stone breakwater extending 1,400 feet in an easterly direction from a point north of the Town Wharf then 2,100 feet in a southeasterly direction for a total length of 3,500 feet. The alternate breakwater would provide protection for a 60-acre anchorage to be dredged shoreward of the breakwater, plus providing protection for the existing locally dredged anchorages. Construction cost of the desired improvement was estimated at $4,200,000 and of the alternate improvement $1,500,000. The existing project provides for a 42-acre anchorage 18 feet deep on the easterly side of the harbor adjacent to Long Beach. This aspect of improvement was authorized by the River and Harbor Act of June 20, 1948. As an item of local cooperation local interests were required to contribute one-third the first cost of construction, estimated at $417,000 (1954). At that time, the town of Plymouth established a fund for the purpose. No Federal funds were appropriated for construction in the next ten-year interval. In the meanwhile, the town expended its funds for more urgent purposes. In 1948, it became apparent that the type of shipping for which the anchorage was designed was rapidly becoming obsolete in this locality. Therefore, local interests requested modification of the project to provide anchorage for recreational and fishing craft in a more accessible part of the harbor. The modification was requested as a substitute for the authorized anchorage which is locally considered as inaccessible and not protected sufficiently for the shallower draft boating now prevalent in the locality. The present study reveals the justification of this phase of improvement. Therefore, it is considered that the project should be modified to eliminate the authorized 18-foot anchorage.

89. Benefits to be derived from improvement are partly general and partly local in nature. General benefits of $6,000 were derived from reduction in annual average storm damage to the fishing fleet. No benefits were derived from increased catch of fish by the existing fishing fleet. It was determined, however, that as a result of improvement, 3 new draggers and 5 new lobster boats would locate in Plymouth Harbor. Annual benefits from the increased catch for these boats have been estimated as $42,000 for the draggers and $12,500 for the additional lobster boats. It was also estimated that as a result of improvement, 5 draggers would transfer from other harbors. At the present time, these boats are based in, and land, their fish at other ports. Trucking charges to markets in New York and southwestern New England are higher from these ports than Plymouth. Since average boat-time spent to and from the various fishing grounds from these other ports and Plymouth is the same, elimination of additional trucking charges will be a considerable factor in the decision to transfer. Benefits resulting from elimination of the higher trucking charges from present bases to market have been evaluated and amount to $14,300 annually. The recreational fleet will also benefit from improvement. In the same manner as the fishermen, the existing recreational fleet will be protected from storm damage. The average annual

benefit from this source has been evaluated as $6,000 of which $3,000 is considered general and $3,000 local. Benefits are also considered to accrue to the recreational fleet, both prospective and existing, from increased use of the harbor, the addition of new boats and additional transient boating. Total recreational benefits amount to $47,000 of which $23,500 are considered local and $23,500 general.

90. The apportionment of first cost of construction was predicated on the ratio of local to general benefits. Local benefits were 20 percent and general benefits 80 percent of the total evaluated benefits. Therefore, costs of construction were prorated in the same manner. Total first cost of construction was estimated at $1,500,000. The local share of construction was estimated as 20 percent of $1,500,000 or $300,000, leaving $1,200,000 as the Federal share.

91. Local interests should be required to hold and save the United States free from damages that may result from construction and subsequent maintenance of the project. Local interests should also provide lands, easements and rights-of-way necessary for construction and maintenance of the project.

CONCLUSIONS

92. The Division Engineer finds that additional protected anchorage is both necessary and economically jusiified for the existing and prospective fishing and recreational fleets. He concludes that the additional protected anchorage would be feasibly effected by constructing a stone breakwater, extending from a point north of the Town Wharf, and 300 feet offshore, easterly for 1400 feet then turning southeasterly for 2,100 feet, for a total distance of 3,500 feet, and dredging an anchorage basin south of the breakwater about 60 acres in area. The benefit-cost ratio is 1.8. The total first cost of construction is $1,500,000, exclusive of aids to navigation and preauthorization studies.

93. Inasmuch as the local benefits to be derived are 20 percent of the total benefits, it is considered that local interests should, in the same proportion, share in the first cost of construction. First cost of construction is presently estimated at $1,500,000 (July 1961). The local cash contribution should, therefore, be 20 percent of $1,500,000 or $300,000. The Division Engineer finds also that the presently authorized 18-foot anchorage is neither necessary in the best interests of navigation, nor desired by local interests.

RECOMMENDATIONS

94. The Division Engineer recommends that the existing project for Plymouth Harbor be modified to provide for the following:

(a) A rubble stone breakwater 3,500 feet long, top width 5 feet, top elevation 15.0, extending easterly from a point north of the Town Wharf.

(b) An 8-foot deep anchorage, 60 acres in area south of the breakwater.

(c) Elimination of the authorized 18-foot anchorage from the existing project, as no longer necessary.

The total estimated construction cost of the project is $1,500,000 with $10,000 additional annual maintenance.

This modification is recommended subject to the condition that local interests:

(a) Make a cash contribution of 20 percent of the construction cost, currently estimated at $300,000.

(b) Maintain existing public landings open to all on equal terms and provide without cost to the United States, all necessary mooring facilities in the anchorage.

(c) Provide, without cost to the United States, all lands, easements, and rights-of-way necessary for construction and maintenance of the project and,

(d) Hold and save the United States free from damages that may result from construction and subsequent maintenance of the project and,

(e) Agree to furnish spoil disposal areas, upon request of the Chief of Engineers if it is determined after detailed studies that such areas are necessary, and without cost to the United States furnish any such areas required, including such dikes, bulkheads and embankments as may be necessary for the initial construction and maintenance of the project.

SEYMOUR A. POTTER, JR.
Brigadier General, U. S. Army
Division Engineer

SURVEY OF PLYMOUTH HARBOR, MASSACHUSETTS

APPENDIX A

ESTIMATE OF FIRST COST

1. The first cost of the recommended improvement is given below. Federal construction consists of the provision of a core-filled rubble stone breakwater 3,500 feet long, and dredging a 60-acre anchorage basin south of it to a depth of 8 feet. The United States Coast Guard has advised that one additional buoy will be required to mark the anchorage.

2. Probings made during the study consist of mud and sand. It is anticipated that dredging will be accomplished by bucket dredge with the material spoiled at sea. Such action will be necessary as the Commonwealth of Massachusetts Division of Fisheries and Game recommends that no fill be placed on the marsh or harbor flats areas. Their recommendations are shown in Appendix "B". Dredging quantities are in terms of in-place measurement and include an allowance of 1 foot of overdepth. Side slopes of 1 vertical on 3 horizontal were used. Cost estimates are based on July 1961 price levels.

3. The detailed estimate of cost is as follows:

PROJECT COST ESTIMATE
(Thousands of Dollars)

Cost Account Number	Item	Cost Estimate ($1,000) (July 1961)
02	Channels - 8' Anchorage (Dredging 620,000 cy of mud and sand at $1.10 - 682.0 (Contingencies at 15% - 102.0)	784.0
10	Breakwater (Rubble Stone) 76,000 tons of stone at 7.00 - 532 Contingencies at 15% - 78	610.0
29	Pre Authorization Studies	10.0
30	Engineering and Design	20.0
31	Supervision and Administration	86.0
	Total Cost (Corps of Engineers Funds and non-Federal Contributions)	$1,510.0
	Non-Federal Contribution - 20%	$ 300.0

R 8/61

Total Non-Federal Costs	
Lands and Damages	0
Relocations	0
Other	
(Cash Contribution (20% of $1,500.0)	300.0
Public Landing	0.0
Total Non-Federal Costs	300.0
Summary of Estimated Costs	
Federal Cost	
Corps of Engineers	1,210.0
U. S. Coast Guard	1.0
Required Non-Federal Costs	
Cash Contribution	300.0
Total Federal and non-Federal Costs	1,511.0

SURVEY OF PLYMOUTH HARBOR, MASSACHUSETTS

APPENDIX B

FISH AND WILDLIFE SERVICES

1. The U. S. Fish and Wildlife Service and the Commonwealth of Massachusetts Division of Fisheries and Game were requested to comment on the proposed improvement. Their comments are contained in the following pages.

ADDRESS ONLY THE
REGIONAL DIRECTOR

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 TEMPLE PLACE
BOSTON, MASSACHUSETTS

NORTHEAST REGION
(REGION 5)
MAINE
NEW HAMPSHIRE
NEW YORK
VERMONT
PENNSYLVANIA
MASSACHUSETTS
NEW JERSEY
RHODE ISLAND
DELAWARE
CONNECTICUT
WEST VIRGINIA

December 29, 1959

Division Engineer
New England Division
U. S. Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

The navigation improvements on Plymouth Harbor, Massachusetts, as outlined in your letter dated October 13, 1959, have been considered by the Bureaus of this Service and we conclude they will have no deleterious effect on the marine resources or wildlife of the area.

Sincerely yours,

John S. Gottschalk

John S. Gottschalk
Regional Director

ADDRESS ONLY THE
REGIONAL DIRECTOR

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 TEMPLE PLACE
BOSTON, MASSACHUSETTS

NORTHEAST REGION
(REGION 5)
MAINE
NEW HAMPSHIRE
NEW YORK
VERMONT
PENNSYLVANIA
MASSACHUSETTS
NEW JERSEY
RHODE ISLAND
DELAWARE
CONNECTICUT
WEST VIRGINIA

February 16, 1960

Division Engineer
New England Division
U. S. Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts

Dear Sir:

We have investigated the economic justification used in connection with the Plymouth Harbor navigation study as outlined in your letter to us dated January 8, 1960. You have estimated that 5 new lobster boats and 3 new draggers would be added to the local fishing fleets. It was considered that each dragger lands an average of 312.5 tons of fish annually. Three new draggers would land 937.5 tons of fish, increasing the total annual catch landed at Plymouth Harbor by 16 percent. It was considered that the 5 new boats would land an additional 62,500 pounds of lobster annually, or an increase of about 17 percent in relation to the present landings of about 180 tons.

In our opinion the estimated increase in fishing activity and landings that might be expected at Plymouth Harbor is entirely reasonable. Present fishery trends are toward smaller vessels, landing high-quality fresh fish. Plymouth is well situated for such activity. There is, however, a definite possibility that increased landings at Plymouth would be at the expense of Provincetown. There are distribution problems in handling fish at Provincetown, and the same fish landed at Plymouth would be more readily available to the markets.

A marked improvement in the harbor facilities at Plymouth might result in an even greater use than that suggested. For this reason (the fact that your analysis is conservative, if anything) we do not feel that the possibility of competition with Provincetown is a significant factor in the economic justification for improvement of Plymouth Harbor. Obviously, however, we cannot assign benefits to harbor improvements in cases where the effect of such improvements is primarily to divert landings from other ports.

These comments, together with our letter dated December 29, 1959, constitute our report on the plan of improvement for Plymouth Harbor, Massachusetts.

Sincerely yours,

M. A. Marston
Chief, Division of Technical Services

The Commonwealth of Massachusetts

Division of Fisheries and Game

73 Tremont Street, Boston 8

October 16, 1959

Mr. John Wm. Leslie, Chief
Engineering Division
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham 54, Mass.

Dear Mr. Leslie:

Your considered improvements, resulting from your navigation study of Plymouth Harbor, Massachusetts, have been reviewed by this Division.

I would like to report that, with one exception, we have no objections to your proposals as outlined in your letter of October 13th. You state that present planning calls for dumping the dredged material offshore but that you may find it more feasible to utilize the nearby marsh or harbor flats area.

Our recommendation is that you continue with your present plans for offshore deep water disposal. We consider Plymouth Harbor, with the marsh and harbor flats areas, to be one of the most valuable migratory waterfowl habitats on the Massachusetts shoreline. Dumping of dredged material on the marshes bordering the harbor, or on the flats in the harbor, would destroy this high waterfowl value.

Since we have no information concerning the effects on marine fish or shell fish, it is suggested that you contact the Massachusetts Division of Marine Fisheries, 15 Ashburton Place, Boston for this information.

Very truly yours,

CHARLES L. McLAUGHLIN
DIRECTOR

CLM:mg

The Commonwealth of Massachusetts
Department of Natural Resources
Division of Marine Fisheries
15 Ashburton Place, Boston 8

October 29, 1959

Mr. John Wm. Leslie, Chief
United States Army Engineer Division
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Mr. Leslie:

The proposed construction of a breakwater and anchorage at Plymouth has been reviewed by Dr. Matthiessen and me, and we find nothing objectionable in the proposal except the disposal of dredged material on marsh areas.

We feel the preservation of existing marsh areas is absolutely necessary if we are to protect the biological environment necessary for fish and shellfish propagation.

In view of this policy, we sincerely urge that every consideration be given to protect marsh areas and that no dredged material be dumped on them.

On the other hand, if your engineers deem it feasible to dump sand on an intertidal or subtidal area where no damage will result from the material shifting, these areas so produced are usually beneficial to shellfish.

We thank you for the opportunity to comment on this work.

If we can be of further assistance to you, please do not hesitate to call on us.

Sincerely,

Frederick C. Wilbour, Jr.

Frederick C. Wilbour, Jr.
Director

FCW:et

PLYMOUTH HARBOR MASSACHUSETTS

Information called for by Senate Resolution 148, 85th Congress.

Adopted 28 January 1958

1. Navigation Problem. Plymouth Harbor, on the east coast of Massachusetts, is 45 miles south of Boston Harbor. It is the most southerly of three large bays, separated from the Atlantic Ocean by 2 long and narrow sand spits. The harbor has an area of about 2,000 acres, a large part of which is bare at low tide. The harbor is used chiefly by small fishing craft, and in the summer months, by recreational boating.

2. The principal navigational difficulty stems from the exposed condition of the harbor, particularly in a northerly direction. Winds from that direction have a fetch of about 6 miles. Northerly storms are usually the most severe occurring in the locality. These storms have caused considerable boat damage in the past, both in the anchorages and at the wharves.

3. Improvements Considered. In order to provide for sheltered anchorage inside the harbor, local interests requested breakwater protection. To effect this protection, it was proposed that a combination causeway and earth dike be erected. The dike would have a top width of 200 feet, a riprapped side slope on its seaward side, and a retaining sheet steel pile bulkhead on its inner side. The dike would extend from town-owned property north of the Town Wharf for a distance of 1,300 feet due east, then continue southerly, and generally parallel to the main waterfront for a distance of 3100 feet. It was proposed also that the area shoreward of the structure be dredged to a depth of 8 feet, forming a protected anchorage area of about 62 acres. Local interests also requested a rubble stone breakwater 3,000 feet long and south of the main channel. A 72-acre anchorage 8 feet deep would be provided shoreward of this breakwater. Local interests also requested a breakwater 3,000 feet long extending due east from the tip of the sand spit known as Long Beach. Studies of the locally-proposed improvements were made. It was found that, while the protected anchorage requested would be furnished, the costs would be excessive and incapable of economic justification. Therefore, an alternate plan of improvement was studied. This plan would provide essentially the same protection as the requested improvement, at considerably less cost of construction.

4. Recommended Improvement. To provide protected anchorage for the existing and prospective fleets in Plymouth Harbor, the alternate plan is recommended. The alternate plan consists of a core-filled stone breakwater extending 1,400 feet easterly from a point north of

the Town Wharf, then extending southeasterly for 2,100 feet and an anchorage basin 60 acres in area, immediately south of the breakwater. Estimated first costs, annual costs and annual benefits are based on July 1961 price levels, a 50-year project life, a 2-5/8 percent interest rate on Federal funds, and a 3-1/2 percent interest rate on non-Federal funds.

a. Estimated First Cost of Construction

Federal	$1,200,000
Non-Federal	300,000
Total Estimated Cost of Construction	$1,500,000

b.

Estimated Annual Charges	Federal	Non-Federal	Total
Interest and Amortization	$43,800	$12,800	$ 56,600
Additional Maintenance	10,120		10,120
Total Estimated Annual Charges	$53,920	$12,800	$ 66,720

c.

Estimated Annual Benefits	General	Local	Total
Commercial Fishing	$68,800		$68,800
Recreational	20,500	20,500	41,000
Storm Damage			
Fishing Boats	6,000		6,000
Recreational Boats	3,000	3,000	6,000
Total Estimated Annual Benefits	$98,300	$23,500	$121,800

d. Benefit-cost Ratio: 1.8

5. Apportionment of Costs and Local Cooperation. In view of the local benefits to be derived, local interests should be required to contribute in cash 20 percent of the first cost of construction, presently estimated at $300,000 (July 1961). In addition to this requirement, local interests should be required to:

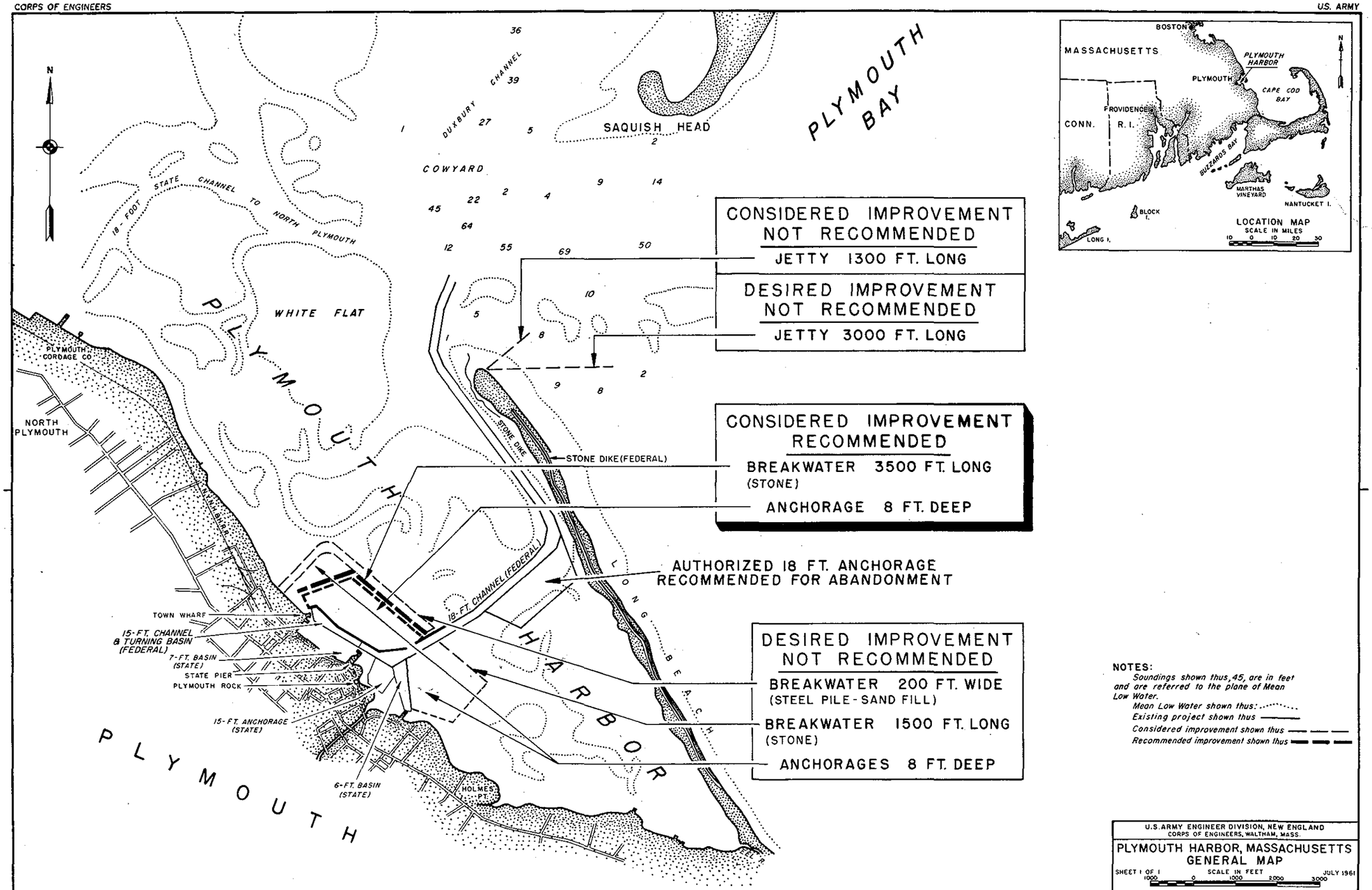
a. Provide, without cost to the United States, all lands, easements, and rights-of-way, necessary for construction and maintenance of the project.

b. Hold and save the United States free from any damages that may result from construction and maintenance of the project, and

c. Agree to furnish spoil disposal areas, upon request of the Chief of Engineers, if it is determined after detailed studies that such areas are necessary, and, without cost to the United States furnish any such areas required, including such dikes, bulkheads, and embankments as may be necessary for the initial construction and subsequent maintenance of the project.

6. Discussion. Local interests have approved the recommended plan and have indicated that the requirements of local cooperation would be met. The recommended measures of improvement would provide a logical and economically feasible means of meeting current and prospective needs of navigation in the harbor. Analysis on the basis of an economic life of 100 years would increase the benefit-cost ratio from 1.8 to 2.3. The project is considered justified on the basis of the studies and criteria in the report. Proposed local cooperation is consistent with other similar projects.

CORPS OF ENGINEERS — U.S. ARMY



NOTES:

Soundings shown thus, 45, are in feet and are referred to the plane of Mean Low Water.

Mean Low Water shown thus:

Existing project shown thus

Considered improvement shown thus

Recommended improvement shown thus

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS, WALTHAM, MASS.

PLYMOUTH HARBOR, MASSACHUSETTS GENERAL MAP

SHEET 1 OF 1 — SCALE IN FEET (1000 0 1000 2000 3000) — JULY 1961

APPROVED: Wm. Ends, CHIEF, ENGINEERING DIVISION

SUBMITTED: W. Ingersoll, CHIEF, SURVEYS BRANCH; L. W. Roberts, CHIEF, RIVER & HARBOR SECT.; Edward J. Mahoney, PROJECT ENGINEER

TO ACCOMPANY SURVEY REPORT DATED: AUGUST 3, 1961

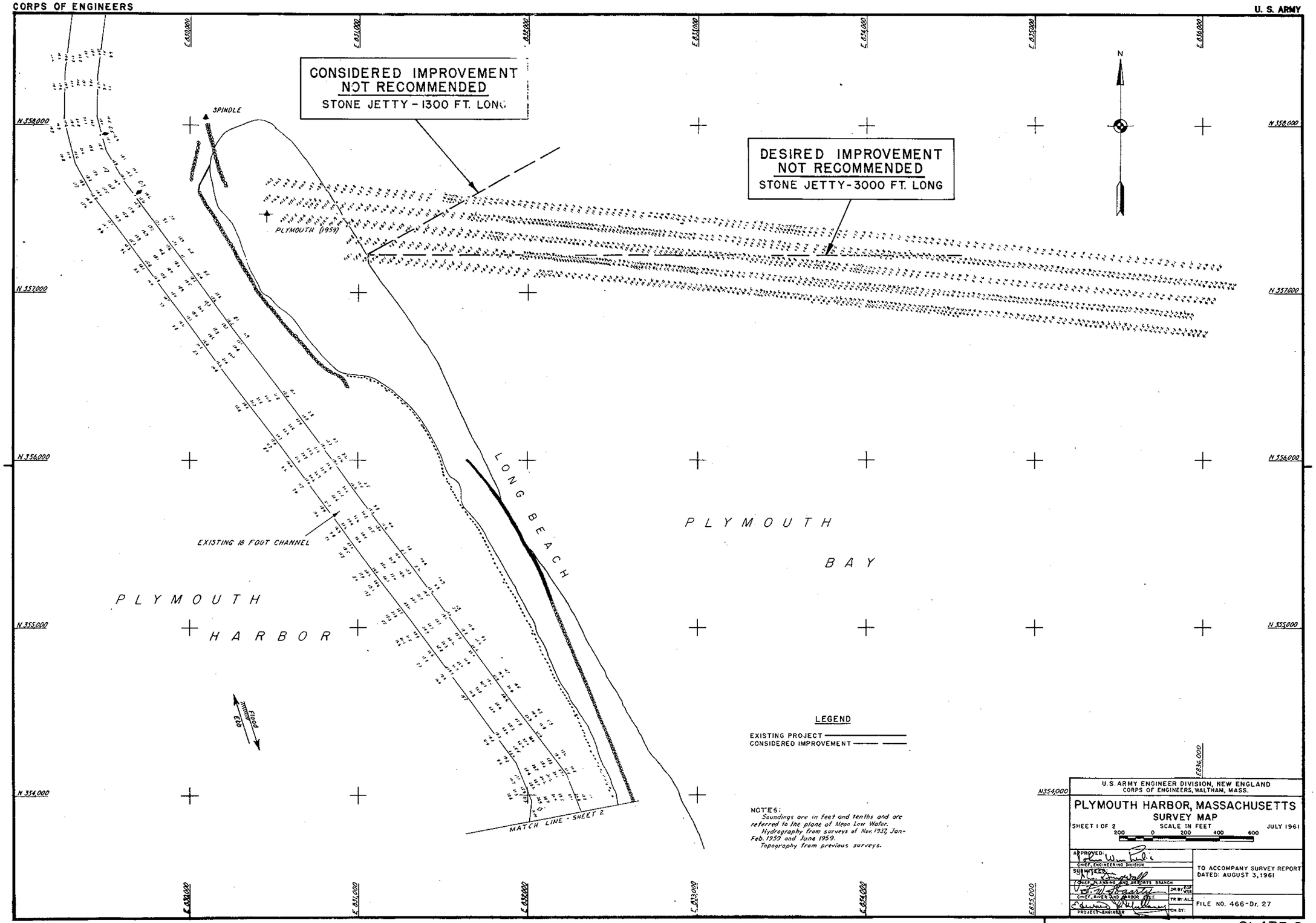
FILE NO. 466-Dr. 27

REV. 7-61

PLATE 1

CORPS OF ENGINEERS

U. S. ARMY



LEGEND

EXISTING PROJECT

CONSIDERED IMPROVEMENT

NOTES:
Soundings are in feet and tenths and are referred to the plane of Mean Low Water.
Hydrography from surveys of Nov. 1937, Jan-Feb. 1959 and June 1959.
Topography from previous surveys.

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS, WALTHAM, MASS.

PLYMOUTH HARBOR, MASSACHUSETTS
SURVEY MAP

SHEET 1 OF 2 — SCALE IN FEET 200 0 200 400 600 — JULY 1961

APPROVED:
CHIEF, ENGINEERING DIVISION

SUBMITTED:
CHIEF, PLANNING AND REPORTS BRANCH

CHIEF, RIVER AND HARBOR SECT.

PROJECT ENGINEER

DR BY: EOP WSB
TR BY: ALC
ICH BY:

TO ACCOMPANY SURVEY REPORT DATED: AUGUST 3, 1961

FILE NO. 466-Dr. 27

PLATE 2

PS OF ENGINEERS

U. S ARMY

DESIRED IMPROVEMENT
NOT RECOMMENDED
BREAKWATER STEEL PILE - SAND FILL
ANCHORAGE 8 FT. DEEP

CONSIDERED IMPROVEMENT
RECOMMENDED
STONE BREAKWATER 3500 FT. LONG
ANCHORAGE 8 FT. DEEP

DESIRED IMPROVEMENT
NOT RECOMMENDED
STONE BREAKWATER 1500 FT. LONG
ANCHORAGE 8 FT. DEEP

N

MATCH LINE - SHEET NO. 1

N 354000

N 353000

E 626000 E 627000 E 628000 E 629000 E 630000 E 631000 E 632000

P-1 P-2 P-3 P-4 P-5 P-6 P-7 P-8 P-9 P-10 P-11 P-12 P-13 P-14 P-15 P-16 P-17 P-18 P-19 P-20 P-21 P-22 P-23 P-24 P-25 P-26 P-27 P-28 P-29 P-30 P-31 P-32 P-33 P-34 P-35 P-36 P-37 P-38 P-39 P-40 P-41

200'

1400'

2100'

Flood Ebb

EXISTING 15 FOOT TURNING BASIN

TOWN WHARF

EXISTING 15 FOOT CHANNEL

RIPRAP

Bulkhead

STATE PIER (1937)

LIMIT OF 18 FOOT CHANNEL

ANCHORAGE LIMITS

15-FOOT MOORING BASIN (STATE-1956)

6-FOOT BASIN (STATE)

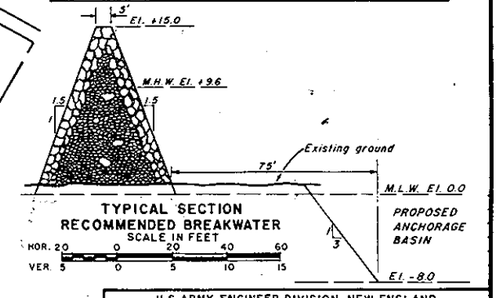
PLYMOUTH ROCK

PLYMOUTH YACHT CLUB

AUTHORIZED 18 FOOT ANCHORAGE RECOMMENDED FOR ABANDONMENT

LIST OF PROBINGS

NUMBER	DEPTH OF WATER	ELEVATION BELOW M.L.W. DEPTH OF PROBE	ELEVATION BELOW M.L.W. PENETRATION	MATERIAL
1				No Probing
2	+0.1	10.5	10.6	Mud light mix sand
3	+1.1	10.5	11.6	"
4	+0.5	10.6	11.1	"
5	+3.0	10.2	13.2	"
6	+3.1	10.5	13.6	"
7	+2.9	10.4	13.3	"
8	1.0	10.1	9.1	"
9	0.9	10.1	9.2	"
10	0.7	10.0	9.3	"
11	0.0	10.2	10.2	"
12	0.2	10.2	10.0	"
13	0.7	10.2	9.5	"
14	1.3	10.2	8.9	"
15	1.3	10.2	8.9	"
16	0.9	10.2	9.3	"
17	1.3	10.2	8.9	"
18	7.6	10.2	2.6	"
19	1.1	10.2	9.1	"
20	1.3	10.1	8.8	"
21	1.3	10.1	8.8	"
22	1.1	10.1	9.0	Mud light mix sand
23	0.8	10.0	9.2	"
24	+0.9	10.1	11.0	"
25	1.8	10.4	8.6	"
26	2.0	10.3	8.3	"
27	1.5	10.2	8.7	"
28	1.0	10.3	9.3	"
29	8.8	10.1	1.3	"
30				No Probing
31	4.1	10.1	6.0	Mud light mix sand
32				No Probing
33	2.0	10.2	8.2	Mud light mix sand
34	1.4	10.1	8.7	"
35	1.4	10.1	8.7	"
36	1.7	10.1	8.4	"
37	2.1	10.1	8.0	"
38	2.2	10.1	7.9	"
39	1.1	10.2	9.1	"
40	2.3	10.3	8.0	"
41	1.4	10.2	8.8	"



TYPICAL SECTION
RECOMMENDED BREAKWATER
SCALE IN FEET

NOTE:
For gen. notes see Sheet No. 1

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS, WALTHAM, MASS.

PLYMOUTH HARBOR, MASSACHUSETTS
SURVEY MAP

SHEET 2 OF 2 — SCALE IN FEET 200 0 200 400 600 — JULY 1961

APPROVED:
CHIEF, ENGINEERING DIVISION
SUBMITTED:
CHIEF, PLANNING AND REPORTS BRANCH
CHIEF, RIVER AND HARBOR SECT.
PROJECT ENGINEER
DR. BY: FOR WSG
TR. BY: ALC
CH. BY:

TO ACCOMPANY SURVEY REPORT DATED: AUGUST 3, 1961

FILE NO. 4[illegible] 27

REV. 7-61

PLATE 3